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Median artery revisited

M. RODRÍGUEZ-NIEDENFÜHR[1], J. R. SAÑUDO[1], T. VÁZQUEZ[2], L. NEARN[3], B. LOGAN[3] AND I. PARKIN[3]

[1] *Unit of Anatomy and Embryology, School of Medicine, Autonomous University of Barcelona,*
[2] *Department of Morphological Sciences I, School of Medicine, University Complutense of Madrid, Spain, and*
[3] *Department of Anatomy, Cambridge University, UK*

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ABSTRACT

This study confirms that the median artery may persist in adult life in 2 different patterns, palmar and antebrachial, based on their vascular territory. The palmar type, which represents the embryonic pattern, is large, long and reaches the palm. The antebrachial type,which represents a partial regression of the embryonic artery is slender, short, and terminates before reaching the wrist. These 2 arterial patterns appear with a different incidence. The palmar pattern was studied in the whole sample (120 cadavers) and had an incidence of 20%, being more frequent in females than in males (1.3:1), occurring unilaterally more often than bilaterally (4:1) and slightly more frequently on the right than on the left (1.1:1). The antebrachial pattern was studied in only 79 cadavers and had an incidence of 76%, being more frequent in females than in males (1.6:1); it was commoner unilaterally than bilaterally (1.5:1) and was again slightly more prevalent on the right than on the left (1.2:1). The origin of the median artery was variable in both patterns. The palmar type most frequently arose from the caudal angle between the ulnar artery and its common interosseous trunk (59%). The antebrachial pattern most frequently originated from the anterior interosseous artery (55%). Other origins, for both patterns, were from the ulnar artery or from the common interosseous trunk. The median artery in the antebrachial pattern terminated in the upper third (74%) or in the distal third of the forearm (26%). However, the palmar pattern ended as the 1st, 2nd or 1st and 2nd common digital arteries (65%) or joined the superficial palmar arch (35%). The median artery passed either anterior (67%) or posterior (25%) to the anterior interosseous nerve. It pierced the median nerve in the upper third of the forearm in 41% of cases with the palmar pattern and in none of the antebrachial cases. In 1 case the artery pierced both the anterior interosseous and median nerves.

Key words: Median nerve; vasculature.

INTRODUCTION

The median artery is a transitory vessel that represents the arterial axis of the forearm during early embryonic life. It normally regresses in the second embryonic month (DeVriese, 1902; Müller, 1903). Its persistence in the human adult has been recorded in 2 different patterns: as a large, long vessel (palmar type) which reaches the hand; or as a small and short vessel (antebrachial type) which ends before reaching the wrist joint (Salmon & Dor, 1933; Valdecasas-Huelin et al. 1979).

The incidence of the palmar type has been reported as ranging from 1.5 to 50% of cases (Tandler, 1897; Wheathersby, 1956; Coleman & Anson, 1961; Pecket et al. 1973; Karlsson & Niechajev, 1982; Srivastava & Pande, 1991; Henneberg & George, 1992*a*; Schmidt & Lanz, 1992; George & Henneberg, 1996; Kopuz et al. 1997). The antebrachial type has been described with a higher incidence, ranging from 70 to 100% of cases (Salmon & Dor, 1933; Sunderland, 1945; Blunt, 1959; Valdecasas-Huelin et al. 1979). Only 2 anatomical studies evaluate the existence of both median arterial patterns in the same sample but in a small number of cadavers and without any information about sex and side (Salmon & Dor, 1933; Valdecasas-Huelin et al. 1979).

The clinical importance of the persistence of this

Correspondence to Dr J. R. Sañudo, Unitat d'Anatomia i Embriologia, Facultat de Medicina, Universitat Autònoma de Barcelona, 08193-Bellaterra (Barcelona), Spain.

artery at wrist level is well documented as a cause of the carpal tunnel syndrome (Chalmers, 1978), but it has also been associated with the 'pronator teres syndrome' in cases where the persistent median artery pierces the median nerve in the proximal third of the forearm (Gainor & Jeffries, 1987). This vasculo-nervous relationship has been described in anatomical studies as an occasional finding (Müller, 1903; Adachi, 1928; Sañudo et al. 1994) or with a markedly different incidence, ranging from 11% to 23% (McCormack et al. 1953; Keen, 1961; Srivastava & Pande, 1991; Rodriguez-Baeza et al. 1995). Curiously, the relationship of the persistent median artery with the anterior interosseous nerve or with supernumerary muscles has never been considered. This relationship could be important in such clinical conditions as the anterior interosseous syndrome. Moreover, other anatomical aspects such as the origin, or the termination, of the artery have been described with great variability.

The aims of the present study are to establish the pattern of the median artery in a large sample in terms of sex and side, and also to provide a more accurate account of its detailed morphology and relationships.

MATERIAL AND METHODS

Over a 3 y period (1995–1997) a total of 120 embalmed cadavers (240 upper limbs with an equal right/left distribution) were examined. They had been partially dissected by Cambridge preclinical medical students, and then further dissected using magnification. The sex distribution was 58 males and 62 females. The age of death ranged from 57 to 100 y with a mean of 85 y. The vascular pattern in the hand could not be established in 6 upper limbs as it had been disrupted by previous student dissection. In the sample from 1995 (41 cadavers), only the existence of a large median artery which reached the palm of the hand was studied, but in the samples from 1996 and 1997 (79 cadavers), the small median arteries which did not reach the palm were also studied.

Statistical comparisons between percentages were performed by the χ^2 test. $P < 0.05$ was regarded as statistically significant.

RESULTS

As in earlier studies, 2 different median arterial patterns based on length, diameter and vascular territory, were identified: the palmar type, which reached the palm (Fig. 1) and the antebrachial, which terminated before reaching the wrist (Fig. 2). The 2 types will be described separately.

Palmar type

This was found in 24 (20%) cadavers (11 male, 13 female) of the whole sample (120 cadavers). In 5 cadavers it was bilateral and in 19 unilateral (10 right and 9 left). Therefore, the artery was found in 29 (12%) of the 240 upper limbs (Table 1). The χ^2 test did not show statistically significant differences between male and female subjects ($\chi^2 = 0.639$, $P = 0.424$), right and left side ($\chi^2 = 0.039$, $P = 0.843$), but did show statistically significant differences between its presence unilaterally and bilaterally ($\chi^2 = 8.167$; $P = 0.004$).

The origin of the artery with this palmar pattern was most frequently at the caudal angle between the ulnar artery and the common interosseous trunk (Fig. 1*C*). However, the artery was also seen arising directly from the ulnar artery (Fig. 1*A*), and less frequently from the common interosseous trunk (Table 2).

The vessel coursed distally to lie alongside the median nerve in the upper third of the forearm and then continued its distal course between the anterior surface of the median nerve and the deep surface of flexor digitorum superficialis (Fig. 1). In the upper third of the forearm, the median artery passed in front of the anterior interosseous nerve in 8 cases (67%), behind it in 3 cases (25%) and pierced it (Fig. 1*C*) in 1 case (8%). The artery pierced the median nerve from posterior to anterior (Fig. 1*C*) in 12 cases (41%).

In the distal third of the forearm the median artery emerged between the tendon of flexor carpi radialis and the middle finger tendon of flexor digitorum superficialis. At the wrist it passed deep to the flexor retinaculum, passed through the carpal tunnel and entered the palm. Its distal distribution in the forearm and hand could only be determined in 23 cases (out of 29) as 6 cases were damaged by previous student dissection.

The artery ended in the hand by joining the superficial palmar arch in 8 (35%) cases or by forming some of the common digital branches in 15 (65%) cases. When the artery participated in the superficial palmar arch, it was a slender trunk (Fig. 1*A*). When it did not join the arch, it terminated as the 1st and 2nd common digital arteries (Fig. 1*B*) in 13 cases (57%), the 1st common digital artery in 1 case (4%) and the 2nd common digital artery in 1 case (4%).

The calibre of the palmar type ranged from 1.2 to 3 mm at its origin and from 0.5 to 1 mm at its

termination in the palm, with the exception of 1 case in which it formed a plexiform pattern under the flexor retinaculum before joining the arch as a single, slender trunk.

Antebrachial type

This was found in 60 (76%) cadavers (18 male, 42 female) in the samples from 1996 and 1997 (79 cadavers). In 24 cadavers it was bilateral and in 36 unilateral (20 right, 16 left). Therefore the artery was found in 84 (53%) of the 158 upper limbs (Table 1).

The χ^2 test showed a statistically significant difference between male and female subjects ($\chi^2 = 8.748$; $P = 0.003$), but not between the right and left sides ($\chi^2 = 0.407$; $P = 0.524$) or between its presence unilaterally and bilaterally ($\chi^2 = 2{,}4$; $P = 0.121$).

The origin of the artery in this antebrachial pattern was most frequently directly from the anterior interosseous artery (Fig. 2*B*), followed by an origin from the caudal angle between the ulnar artery and the origin of the common interosseous trunk (Fig. 2*A*), and less frequently directly either from the common interosseous trunk or from the ulnar artery (Table 2).

In the upper third of the forearm the artery coursed distally to lie alongside the median nerve but never pierced the nerve. (Fig. 2). In 62 (74%) cases, the artery ended in the middle third of the forearm within the median nerve sheath. In 22 (26%) cases it reached the distal forearm to terminate within the flexor tendon sheaths and to remain in the median nerve sheath as only a very thin branch. Its calibre ranged from 0.3 to 2 mm at its origin.

In 1 case, 2 median arteries were found in the forearm (Fig. 2*A*). The proximal one arose from the ulnar, and the distal from the caudal angle between the ulnar artery and the origin of its common interosseous trunk. Both vessels passed in front of the anterior interosseous nerve, the proximal one ending in the upper third of the median nerve, and the distal in the middle third of the forearm (Fig. 2*A*).

In both patterns (palmar and antebrachial) the median artery, just after its origin, gave a collateral trunk which passed in front of the anterior interosseous nerve, and behind or in front of the median nerve (Figs 1*A*, 2) to end on the posterior surface of flexor digitorum superficialis. This collateral trunk, in its distal course, gave several branches to the superficial and deep forearm flexor muscles (Fig. 2).

In 23 cases, the median artery was related to an accessory head of flexor pollicis longus (FPL), or to an accessory head of flexor digitorum profundus (FDP), or to both (Figs 1*B* and 2*B*). The most frequent pattern was a median artery passing in front of FPL and the less frequent was an artery passing behind FDP (Table 3).

DISCUSSION

Our results confirm the descriptions of other authors, that the median artery may persist into adult life as 2 different patterns, palmar and antebrachial (Salmon & Dor, 1933; Valdecasas-Huelin et al. 1979). In the palmar type the artery reaches the palm of the hand and in the antebrachial it terminates before reaching the wrist.

The median artery has been considered in 2 different functional roles: (1) as a nutrient artery for the median nerve (Sunderland, 1945) or (2) as an arteria comitans (satellite) chiefly concerned with the supply of structures other than the median nerve rather than as a true nutrient artery (Tonkoff, 1907; Ramage, 1927; Blunt, 1959). Our results support the latter interpretation because the artery along its course as a satellite of the median nerve gave off branches either to the nerve or to the muscles of the region. We can therefore consider the terms median artery and arteria comitans nervi mediani as synonyms.

Both patterns appeared with a very different incidence. The palmar was found in 12% of cases, which is between the 2 major groups of incidence given by other authors, 1.5–10% (Quain, 1844; Adachi, 1928; McCormack et al. 1953; Coleman & Anson, 1961; Srivastava & Pande, 1991) or 18–50% (Salmon & Dor, 1933; Pecket et al. 1973; Henneberg & George, 1992*a*; George & Henneberg, 1996; Kopuz et al. 1997). The antebrachial pattern was found in 76% of cases, similar to other anatomical reports (Salmon & Dor, 1933; Valdecasas-Huelin et al. 1979), with the exception of 1 author who considered it as constant (Blunt, 1959).

The median artery with an antebrachial pattern has not previously been studied in relation to sex and side. Our study shows that it is more frequent in females but there are no differences related to its presence unilaterally or bilaterally. The median artery with a palmar pattern, in relation to sex and side, has been previously recorded as showing, as in our study, no differences between males and females (Henneberg & George, 1992*a*, *b*; George & Henneberg, 1996). However, the artery has been more frequently described as bilateral than unilateral (Henneberg & George, 1992*a*; George & Henneberg, 1996) or without differences between sides (Henneberg & George, 1992*b*).

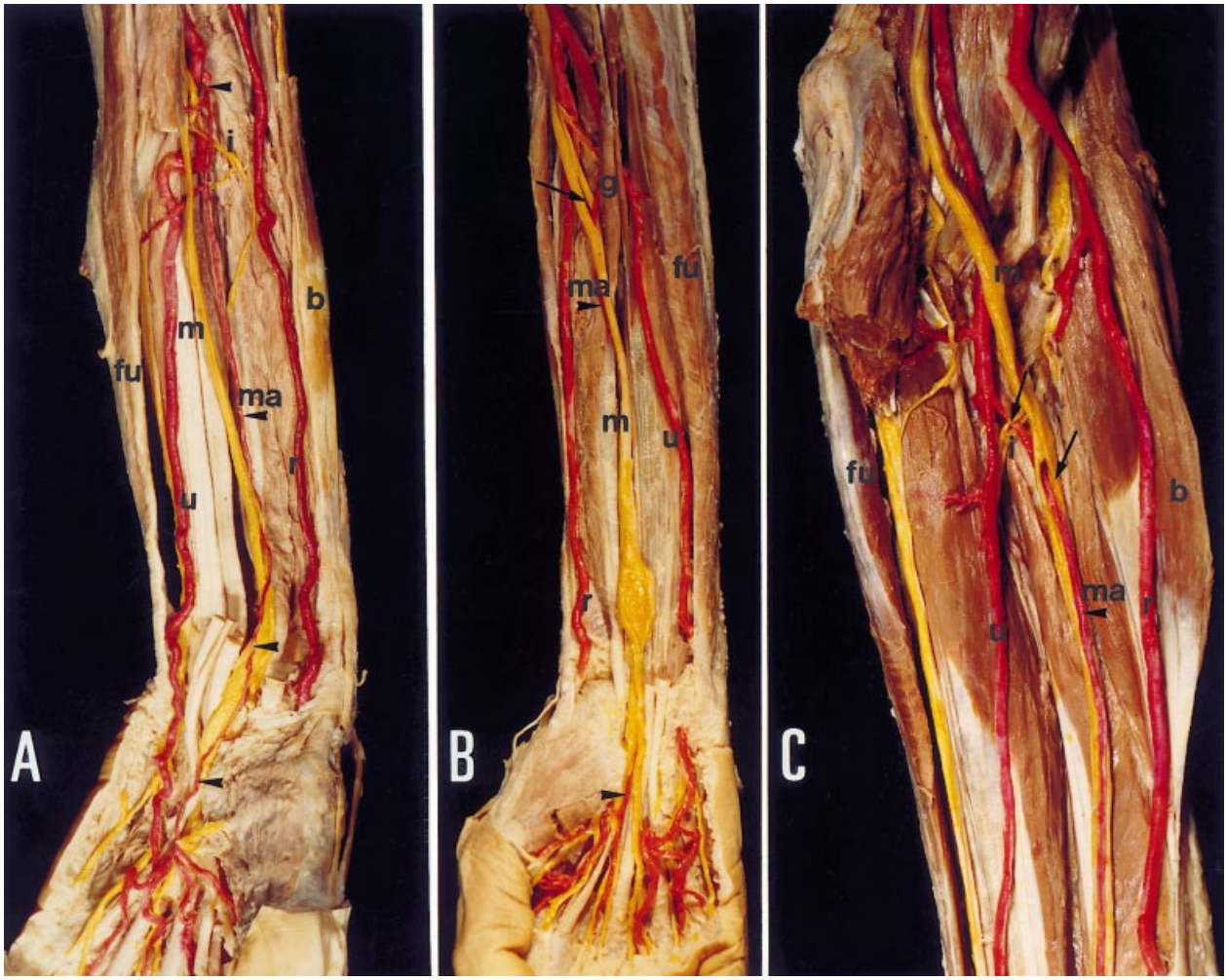

Fig. 1. Anterior view of the forearm after removing the superficial forearm flexor muscles. (*A*) Palmar pattern of median artery forming the superficial palmar arch. (*B*) Palmar pattern of median artery forming the 1st–2nd common digital arteries (arrow shows piercing of median nerve). (*C*) Palmar pattern of median artery piercing the median and anterior interosseous nerves (arrows). b, brachioradialis; fu, flexor carpi ulnaris; r, radial artery; u, ulnar artery; ma, median artery (arrowheads); m, median nerve; i, anterior interosseous nerve; g, Gantzer's muscles.

Table 1. *Distribution of the palmar and antebrachial pattern of the median artery related to sex and lateralisation*

	Palmar type (n = 120)			Antebrachial type (n = 79)	
	Left	Right		Left	Right
Male (n = 58)	6 (10%)	6 (10%)	Male (n = 35)	14 (40%)	14 (40%)
Female (n = 62)	9 (14.5%)	8 (13%)	Female (n = 44)	26 (59%)	30 (68%)
Total (n = 120)	15 (12.5%)	14 (12%)	Total (n = 79)	40 (51%)	44 (56%)

These results, which contradict our findings, could be explained by a heterogeneity between populations that may be due to allelic variation of the genes regulating this anatomical anomaly in the case of the reports based on a multiethnic samples described imprecisely as 'South African Negro' (Henneberg & George, 1992*a*; George & Henneberg, 1996). On the other hand, the differences with the other report based on a sample of the South African white population (Henneberg & George, 1992*b*) could be explained in the light of a founder effect, so that any anatomical variation or anomaly has persisted because of re-

Fig. 2. Anterior view of the superior third of the forearm after removing the superficial forearm muscles. (*A*) Antebrachial pattern of median artery represented by 2 branches. (*B*) Antebrachial pattern of median artery anterior to Gantzer's muscles. b, brachioradialis; r, radial artery; u, ulnar artery; ma, median artery (arrowheads); m, median nerve; i, anterior interosseous nerve; g, Gantzer's muscle.

tention of traits in the population introduced by a common ancestor (Cavalli-Sforza et al. 1994).

The origin of the median artery has previously been described as arising from the ulnar, anterior interosseous, common interosseous, the caudal angle between the ulnar and common interosseous, and from the radial arteries (Quain, 1844; Ramage, 1927; Adachi, 1928; Wankoff, 1962; Henneberg & George, 1992*a*; Wood et al. 1997) but without mention of the incidence, with the exception of 2 studies (Salmon & Dor, 1933; Valdecasas-Huelin et al. 1979). Our results show a difference between the origins of the 2 patterns. For the palmar pattern the origin most frequently was from the caudal angle between the ulnar artery and its common interosseous trunk (59%), and for the antebrachial pattern from the anterior interosseous artery (55%). Origins from the brachial and superficial brachial arteries have also been described (Schwyzer & de Garis, 1935; Pabst & Lippert, 1968) but these were not found in the present study.

The course of the median artery in the forearm was found to be the same as described by all authors, i.e. between the anterior surface of the median nerve and the deep surface of flexor digitorum superficialis. However, it has also been described as a superficial vessel anterior to the superficial forearm flexors (Gruber, 1867). We did not find an example of this type in the present study. When the artery adopts the antebrachial pattern it terminates in the upper third of the forearm within the median nerve sheath in 74% of cases and in the distal third of the forearm within the flexor tendon sheaths or as a very thin branch in the median nerve sheath in 26%. These incidences are very different from those reported previously (Valdecasas-Huelin et al. 1979) but this could be due to the fact that the arteries are so thin, and it is difficult to establish exactly where they end in spite of performing the dissection under magnification.

In this present report, 65% of palmar patterns of the median artery ended as the 1st, 2nd or 1st and 2nd

Table 2. *Origins of the palmar and antebrachial patterns of the median artery*

Origin	Palmar type (n = 29)	Antebrachial type (n = 84)
AIA	4 (14%)	46 (55%)
Tripoid	17 (59%)	26 (31%)
Interosseous trunk	2 (7%)	10 (12%)
Ulnar artery	5 (17%)	2 (2%)
Radial artery	1 (3%)	—

AIA, anterior interosseous artery; tripoid, caudal angle between the ulnar artery and common interosseous trunk.

Table 3. *Relationship of the median artery (MA) to accessory heads of the flexor pollicis longus (FPL) or flexor digitorum profundus (FDP) (Gantzer's muscles)*

MA anterior to FPL	13 (57%)
MA anterior to FDP	3 (13%)
MA anterior to FPL and FDP	3 (13%)
MA posterior to FPL	2 (9%)
MA posterior to FDP	1 (4%)
MA posterior to FPL and FDP	1 (4%)

common digital arteries and 35% joined a complete superficial palmar arch. These values are similar to those of Coleman & Anson (1961) but differ widely from other anatomical studies which have described the ending of the palmar pattern in the superficial palmar arch in 80–100% of the cases, and as the 1st–2nd common digital arteries in only 8–20% (Quain, 1844; Valdecasas-Huelin et al. 1979; Kopuz et al. 1997). These differences could be due to the fact that the anastomotic branch running between the median artery and the ulnar artery to complete the arch is very thin and could be easily damaged during dissection.

The median artery in its palmar pattern, as has been mentioned by all authors, passes under the flexor retinaculum, running in the carpal tunnel together with the median nerve and flexor tendons. This relationship has been considered as an aetiologic factor in the carpal tunnel syndrome (Chalmers, 1978). Another important relationship is the piercing of the median nerve by the median artery in the upper third of the forearm. This perforation of the nerve has been described and implicated in the 'pronator teres syndrome' (Gainor & Jeffries, 1987; Jones & Ming, 1988; Proudman & Menz, 1992). This close relationship has previously been mentioned as a casual finding, with an incidence ranging between 11% and 23% (McCormack et al. 1953; Keen, 1961; Srivastava & Pande, 1991; Rodriguez-Baeza et al. 1995). However, our results show it with a higher incidence (41%) and it was always associated with the palmar pattern. Double piercing of the median nerve by the median artery has been described (Adachi, 1928; Keen, 1961) but we did not find a similar case.

Another clinical condition of the forearm is the anterior interosseous nerve syndrome which has not so far been considered in association with the persistence of a median artery. Nevertheless, this possibility should be taken into account as the median artery, soon after its origin, was intimately related with the nerve. This anatomical relationship, not mentioned by previous authors, consisted of crossing in front of the nerve (67%) or behind it (25%) with the exception of 1 case in which the artery pierced the nerve (8%).

Another aspect not evaluated by previous reports is the persistence of the median artery in association with the presence of accessory heads of flexor pollicis longus and flexor digitorum profundus (Gantzer's muscles) and the relationship between them (Jones et al. 1997). Our results show that this association appeared in 20%, with the artery anterior to them in 83% of cases and posterior in 17%. The latter could have some clinical interest based on the possible compression of the artery by the muscle belly.

The persistence of the median artery in the human adult has been considered as the retention of a primitive arterial pattern (DeVriese, 1902; Müller, 1903; Singer, 1933; Lanz & Wachsmuth, 1959). On this basis, we could consider the palmar pattern as the retention of the embryonic pattern (Valdecasas-Huelin et al. 1979) while the antebrachial pattern represents its partial regression (to the middle or lower third of the forearm). In this way it could be suggested that the involution of the median artery follows a distal to proximal direction, and in the latest stage of its regression its presence as a muscle trunk supplying the forearm flexor muscles, as this branch was a common characteristic in both patterns.

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